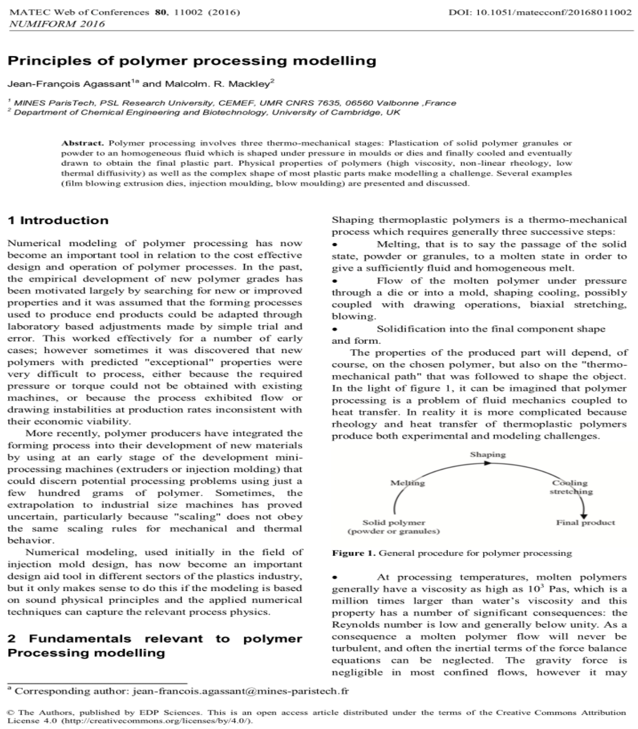
Injection Molding: Technology and Fundamentals (Polymer Processing Society, Progress in Polymer Proc



MATEC Web of Conferences **80**, 11002 (2016) DOI: 10.1051/matecconf/20168011002
NUMIFORM 2016

Principles of polymer processing modelling

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Abstract. Polymer processing involves three thermo-mechanical stages: Plastication of solid polymer granules or powder to an homogeneous fluid which is shaped under pressure in moulds or dies and finally cooled and eventually drawn to obtain the final plastic part. Physical properties of polymers (high viscosity, non-linear rheology, low thermal diffusivity) as well as the complex shape of most plastic parts make modelling a challenge. Several examples (film blowing extrusion dies, injection moulding, blow moulding) are presented and discussed.

1 Introduction

Numerical modeling of polymer processing has now become an important tool in relation to the cost effective design and operation of polymer processes. In the past, the empirical development of new polymer grades has been motivated largely by searching for new or improved properties and it was assumed that the forming processes used to produce end products could be adapted through laboratory based adjustments made by simple trial and error. This worked effectively for a number of early cases; however sometimes it was discovered that new polymers with predicted "exceptional" properties were very difficult to process, either because the required pressure or torque could not be obtained with existing machines, or because the process exhibited flow or drawing instabilities at production rates inconsistent with their economic viability.

More recently, polymer producers have integrated the forming process into their development of new materials by using at an early stage of the development mini-processing machines (extruders or injection molding) that could discern potential processing problems using just a few hundred grams of polymer. Sometimes, the extrapolation to industrial size machines has proved uncertain, particularly because "scaling" does not obey the same scaling rules for mechanical and thermal behavior.

Numerical modeling, used initially in the field of injection mold design, has now become an important design aid tool in different sectors of the plastics industry, but it only makes sense to do this if the modeling is based on sound physical principles and the applied numerical techniques can capture the relevant process physics.

2 Fundamentals relevant to polymer Processing modelling

Shaping thermoplastic polymers is a thermo-mechanical process which requires generally three successive steps:

- Melting, that is to say the passage of the solid state, powder or granules, to a molten state in order to give a sufficiently fluid and homogeneous melt.
- Flow of the molten polymer under pressure through a die or into a mold, shaping cooling, possibly coupled with drawing operations, biaxial stretching, blowing.
- Solidification into the final component shape and form.

The properties of the produced part will depend, of course, on the chosen polymer, but also on the "thermo-mechanical path" that was followed to shape the object. In the light of figure 1, it can be imagined that polymer processing is a problem of fluid mechanics coupled to heat transfer. In reality it is more complicated because rheology and heat transfer of thermoplastic polymers produce both experimental and modeling challenges.

Figure 1. General procedure for polymer processing

- At processing temperatures, molten polymers generally have a viscosity as high as 10^3 Pas, which is a million times larger than water's viscosity and this property has a number of significant consequences: the Reynolds number is low and generally below unity. As a consequence a molten polymer flow will never be turbulent, and often the inertial terms of the force balance equations can be neglected. The gravity force is negligible in most confined flows, however it may

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available technologies used to introduce SCF into the polymer is the .. Injection Molding Manufacturing Process Fundamentals; Society of.Osswald T A and Menges G Materials Science of Polymers for . Y Fundamental study on structure development of thin-wall injection molded analysis of polymer orientation during processing SPE ANTEC Proc. . Polymer Processing The Journal of the Polymer Processing Society XXVIII for gas-assisted injection molding, Advances in Polymer Technology, 14, ( ). fibre orientation in push-pull processed and conventional injection- moulded parts, Injection molding: Technology and fundamentals. immersed in a viscous fluid, Proceedings ofthe Royal Society London, A, ( ).ensure the compatibility of materials and processing technologies throughout these Example of micro injection moulding machine (a) and 1 half mould (b) engineering plastics, Proc. of SPIE 20 - The International Society for Optical . on process variables, Advances in Polymer Technology, 28, 2, pp.Department of Mechanical Engineering, Eindhoven University of Technology, Postbus Steady finite element calculations of a model injection molding flow using a in Proceedings of the 16th Annual Meeting of the Polymer Processing Society, Isayev, A. I., Injection and Compression Molding Fundamentals (Marcel.Injection Molding Process Control, Monitoring, and Optimization Polymer Melt Constitutive Equations for Viscous Flow . 5 Statistical Process Monitoring (SPM) of Injection Molding: Basics. .. founded the Polymer Processing Society (PPS) in March at the University of in the form of proceedings. 2.
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